Assessment of Timber Harvest in Tropical Rainforest Ecosystem of South West Nigeria and Its Implication on Carbon Sequestration

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Abstract

Timber harvest in natural forests and its implications on carbon sequestration were investigated in the Southwestern Nigeria. Data on timber harvest from forest estates for a 3-year period were collected from the official record of States' Forestry Department. The data registered the species, volume and number of timbers exploited during the study period. The data were analyzed accordingly for rate of timber harvest and carbon value of the exploited timbers using existing biomass functions. Values were compared for significant differences among states using one way analysis of variance. The results showed that the most exploited logs, in terms of volume and number of trees, have the highest amount of carbon removal. There was a variation in type of timber species being exploited from each state. The total number of harvested trees from Oyo, Ondo, Ogun, Ekiti and Osun were estimated at 100,205; 111,789; 753; 15,884 and 18,153 respectively. Total quantity of carbon removed for the 3-year period stood at 2.3 million metric tons, and this translated to 8.4 million metric tons of CO₂. The annual carbon and CO₂ removal therefore were estimated at 760,120.73 tons and 2.8 million tons/ year respectively. There were significant differences ($p < 0.05$) in the amount of CO₂ removed from the five states. Based on our result, we inferred that there is increasing pressure on economic tree species and it is plausible that they are becoming scarce from the forests in Southwestern Nigeria. If the present rate of log removal is not controlled, forests could become carbon source rather than carbon sink and the on biological conservation, wood availability and climate change may turn out grave. For the forest to perform its environmental role as carbon sink, urgent conservation measures and logging policies are needed to be put in place.

Key Words: Logging, Timber harvest, Biomass removal, Carbon emission

Introduction

Climate change is posing a dreadful threat to the development and poverty reduction processes in the poorest and most vulnerable regions of the world today. It is considered as one of the most serious threats to sustainable development, with its adverse impacts expected on the environment, human health, food security, economic activity, natural resources and physical infrastructure (IISD 2009;

Wheeler and von Braun 2013). Changes in climatic conditions have significant impacts on the capacity of the forest to provide vital ecosystem services and the well-being of people in African countries where there are low adaptation strategies and mitigation options are the most affected. The low adaptation capacity is not unconnected with the extreme poverty, frequent natural disasters such as droughts and floods and an agricultural system that heavily dependent on rainfall (Huq et al. 2003). For instance, the greatest pro-

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portion of Nigerian population lives in rural areas, and they depend solely on renewable natural resources for survival. The daily activities of this set of people in the forest are culpable of leading to forest degradation and alteration in environmental conditions. Houghton (1991) remarked that the estimates of carbon fluxes from deforestation, land cover change and other disturbances depend on the knowledge of forest carbon stocks prior to the disturbance.

Logging has to do with the harvesting of tree species, and consequently the removal of merchantable above-ground wood biomass that acts as carbon sink from the forest for sawn wood production. Above-ground biomass consists of all living biomass above the soil such as stem, stump, branches, bark, seeds, and foliage while below-ground biomass consists of all living roots excluding fine roots (less than 2 mm in diameter) (Drake et al. 2003; Samalca et al. 2007). Therefore, estimates of the total above-ground biomass in forest ecosystems are critical for carbon dynamics studies, as plant biomass is an important indicator in carbon sequestration. The amount of carbon sequestered can be inferred from the biomass change since 50% of the forest dry biomass is approximately carbon (Losi et al. 2003; Montagu et al. 2005). For this purpose, one needs to know how much biomass is lost or accumulated over time. These estimates provide initial conditions for ecosystem and biogeochemical models that simulate the exchange of carbon and energy between the atmosphere and biosphere (Potter 1999). In addition, biomass estimation is very useful in evaluating the amount of carbon sequestered in the afforestation and reforestation Clean Development Mechanism (AR-CDM) project under the Kyoto Protocol (Hiratsuka et al. 2004). There are two major methods of biomass estimation (the destructive and non-destructive). The destructive method requires felling of trees but the non-destructive method does not require the trees to be felled (Montes et al. 2000). For non-destructive method, tree growth variables are obtained for computing the total volume (m^3). Wood density of tree species, which are available from literature, proved valuable in converting the measured volume into biomass estimate (Feamside 1997; Aboal et al. 2005). Such estimate is used to quantify the amount of carbon removal from the ecosystem from the general knowledge that carbon is always 50% of biomass estimate (Samalca 2007).

Many biomass and carbon estimation studies conducted

focused on aboveground forest biomass (Aboal et al. 2005; Brown 1997; Kraenzel et al. 2003; Laclau 2003; Losi et al. 2003) because it accounts for the majority of the total accumulated biomass in the forest ecosystem. Aboveground tree biomass in turn is estimated using allometric equations (Hiratsuka et al. 2006). However, where allometric equations are not available or feasible, Birdsey (1996) reported that timber cruise estimates of merchantable volume could be converted to biomass and weight by multiplying by a conversion factor for the corresponding region and forest type to determine the carbon mass in living standing trees. Renasingbe and Abasari (2008) also estimated tree biomass, weight and carbon storage from volumes using the same conversion factor. In view of the above, this study focuses on the assessment of above-ground forest biomass from volumes of trees exploited between 2003 and 2005 to estimate the amount of carbon removed during the study period.

Methodology

The study area

This study was carried out in Southwest (SW) Nigeria. It is one of the six geographical zones of country. The zone lies between longitude $2^{\circ} 31'$ and $6^{\circ} 00'$ East and Latitude $6^{\circ} 21'$ and $8^{\circ} 37'N$ (Adekunle and Olagoke 2010) with a total land area of 77,818 km^2 and a projected population of 28,767,752 in 2002 (NPC 1991). SW Nigeria is bounded in the East by Edo and Delta states, in the North by Kwara and Kogi states, in the West by the Republic of Benin and in the south by the Gulf of Guinea. The region is made up of six states, out of the 36 states in the country, and is majorly inhabited by the Yorubas, one of the major tribes in the country. The climate of South West Nigeria is tropical in nature and it is characterized by wet and dry seasons. The temperature ranges between $21^{\circ}C$ and $34^{\circ}C$ while the annual rainfall ranges between 1500 mm and 3000 mm. The wet season is associated with the South West monsoon wind from the Atlantic Ocean while the dry season is associated with the North East trade wind from the Sahara desert. Most of the soils in the study area developed from undifferentiated igneous and metamorphic, pre-cambrian basement complex rocks such as granite, biotite, gneiss, biotite schist, quartz schist and quartzite (Adesodun et al.

2007). The vegetation of South West Nigeria is made up of fresh water swamp and mangrove forest at the belt, the low land in forest stretches inland to Ogun and part of Ondo state while the secondary forest is towards the northern boundary where derived and southern Savannah exists.

Method of data collection

Secondary data for the reserved and unreserved forests (free areas) were used for this study. Forest reserves are portion of forest estates constituted by law and gazette by state or local government. All other woodlands that are not under reservation are referred to as 'free areas' in this study. There are about 1,600 forest reserves in Nigeria that are disproportionately scattered across the states, while the free areas are in form of woodlots, trees on farmlands, private plantations and farm forestry. Entrance and activities in reserves are restricted and controlled by the government but government's control on the free area is limited to the collection of logging fees. Data on the volume (m^3), timber species and number of logs that were exploited, on monthly basis, in three year period (2008 and 2010) were collected from five randomly selected States out of the six States in the zone. The selected States are Ondo, Osun, Oyo, Ekiti and Ogun States. These are states with active logging activities due to the abundance of timber resources in their respective reserves. The Department of Forestry offices located in the State Capital of each of the selected States were visited for data collection. The logging data were collected from official records, files and reports in each state. To gather some additional information on each reserve, the list and management plan of all the reserves in each state were obtained.

Data analysis

Estimation of the Above-ground biomass was carried out by multiplying the volume of each tree with its respective wood density as also done by Feamside (1997). The densities were obtained from literatures which include the Nigerian Standard Code of Practice (1973) and Dinwoodie (1981). The carbon content was estimated as 50% of the dry weight or biomass (MacDicke 1997; Penman 2003; and IPCC 2006). Estimate of annual carbon storage in metric tons was estimated by dividing the total carbon for the three years by three. The relationship be-

tween carbon content and carbon dioxide was used to convert carbon in the wood to CO_2 . This represents the amount of carbon the wood could sequester if they have not been logged or the amount of CO_2 to be removed into the atmosphere if they act as carbon source. The relationship is given as follows:

$$1\text{tC} = 3.67 \text{ t CO}_2 \text{ (NIACS 2008; Renasingbe and Abasari 2008).}$$

The Carbon and CO_2 contents of the individual trees were estimated in metric ton (t). Data collected were analyzed separately for each state and then one way Analysis of Variance (ANOVA) was used to compare and test for significant difference in the estimates. Natural Logarithmic values of all the variables for the fifteen most exploited tree species were used for the comparison. The states' variables that we compared were the number of trees, cubic volume and the amount of carbon. The analyses were performed using SPSS for windows 17.0 version.

Results

The list of reserves in each of the selected states is presented in table 1. As presented in the Table, Ogun State has the largest area of gazetted forest estate under reservation (266,924 ha) in Southwest Nigeria. This is followed by Oyo State (114,441.40 ha). The area of reserved forest in Osun State is about 58,893.32 ha, and the least forest estate was located in Ondo State (3,075.66 ha) which has the highest number of reserves (16). The botanical names of all the species exploited during the 3-year period from South West Nigeria, their individual families, their respective volumes, density, biomass, carbon stock and CO_2 equivalent are presented in Table 2. Generally, *Ceiba pentandra* (16,875) in *Bombacaceae* family was the most exploited species in South West Nigeria. While *Ficus exasperata* (10,402), *Millettia thonningii* (9,261) and *Mitragyna stipulosa* (8,362) were next to *Ceiba pentandra* in the level of exploitation, only 7.56% species recorded one number of exploited tree during the study period. Also, *Ceiba pentandra* (640,021.04 m^3) recorded the highest volume of extraction. This is followed by *Funtumia elastica* (414,449.50 m^3) and *Anogeissus leiocarpa* (387,606.24 m^3). The least volume extraction (0.91 m^3) was

Table 1. List of forest reserves and their respective sizes in the five States

Oyo state		Ondo state		Ogun state		Osun state		Ekiti state	
Forest reserves	Size (ha)	Forest reserves	Size (ha)	Forest reserves	Size (ha)	Forest reserves	Size (ha)	Forest reserves	Size (ha)
Gambari	11,431	Akure	6,993	Area J3, J4, J6	130,550	Ago Owu	32,116	Ogbese	7,252
Ijaiye	28,491	Akure-Ofosu Ext.	2,089	Olokemeji	5,888	Oba hill	3,367	Egbe	1,022
Osho	3,704	Akure-Ofosu	40,145	Arakanga	239	Ila	259	Eda I & II	906
Olokemeji	7,511	Ala	19,943	Ilaro	4,608	Ife North	8,598	Ogotun group	1,569
Lanlate	7,507	Eba Island	1,813	Edun stream	97	Oni	283	Aramoko	1,966
Igangan	39,627	Idanre (OA5)	54,053	Eggua	4,147	Ikeji/Ipetu	3,548	Ikere	1,419
Olaseinde	686	Ifon	28,231	Aworo	21,299			Little Ose	2,662
Olla Hills (Okoo-Iroo)	2,300	Ipele-Idoani	4,144	Imeko	95,488			Ise	5,677
Opara	3,544	Irele (OA11)	3,600	Ohunbe	4,608			Eporo	4,662
Baasi	1,144	Ojigboglobini	2,809					Isan/ Ayede	2,585
		Okeluse	11,137						
		Oluwa (OA1, OA2, OA3, OA6)	87,816						
		Onisere (OA4)	9,842						
		Otu (OA4)	8,490						
		Owo	24,216						
		Oyinmo	2,245						
Total	114,441.40		307,566.00		266,924.00		58,839.32		29,720.00

recorded for about 2.91% species in the study area. In term of biomass, carbon stock and CO₂ removed, *anogeissus leicocarpa* recorded the highest values, and *Cassia siamea*, *Butyrospermum paradoxum* and *Bridelia artroviridis* were noted for the least values of biomass removal.

In Oyo State, *Anogeissus leicocarpus* (6,590) of the family *Combretaceae* was the most exploited species but, *Mansonia altissima* (62) of the family *Sterculiaceae* was the least exploited species. In Ondo State, *Mitragyna stipulosa* (8,353) of the family *Rubiaceae* was the most exploited while *Blighia sapida* (47) of the family *Sapindaceae* was the least exploited species. The most exploited species in Ogun, Osun and Ekiti States was *Ceiba pentandra* in *Bombacaceae* family with 30 trees in Ogun State, 2426 in Osun State and 1584 in Ekiti State. However, 11.5% of the tree species in Osun State, 18.9% of those in Ogun State and 6.67% in Ekiti State had only a tree that was logged during the three year period. For tree volume estimate, the highest annual volume was exploited in Oyo State (1,910,348.33 m³). This is followed by Osun State with an annual volume removal of 713,025.00 m³ and the least, 9,087.03 m³ in Ogun State. The annual volume of wood removed from Ondo and Ekiti

State were estimated at 98,414.87 m³ and 44,875 m³ respectively. For the diversity of logged trees, 57 species, belonging to 29 families, were exploited in Oyo State; 61 species belonging to 24 families were exploited in Ondo State; 74 species in 33 families were removed from Ogun State, 60 species belonging to 25 families were removed from Ekiti State and 130 species in 42 families were exploited in Osun State. Osun was the state with the highest species diversity of the felled logs.

In Oyo State, the highest carbon released was from *Anogeissus leicocarpus* (442,193.85 tons). This is followed by *Cassia siamea* (434,001.26 tons) and the least carbon released was from *Cordia millenii* (2495.31). *Terminalia superba* and *Afzelia africana* recorded the highest carbon release in Ondo State and the estimated values are 31,932.84 and 31,677.39 metric tons respectively. However, *Borassus aethiopica* (4.93 tons) had the least estimated carbon value. In Ogun State, *Albizia zygia* was the most exploited species and as a result, it has the highest amount of CO₂ (2,317.27 tons). Next to *Albizia zygia* in term of carbon release is *Milicia excelsa* (2,307.40 tons) while *Cedrella odorata* which was the least exploited species also has the least amount of

Table 2. List of exploited tree species, families, and quantity of carbon and CO₂ released for a 3-year period in southwest Nigeria

S/N	Family	Tree Species	Number of tree	Volume (m ³)	Density (kg/m ³)	Biomass (tons)	Carbon stock (tons)	CO ₂ (tons)
1	Anacardiaceae	<i>Lannea acida</i>	36	2719.776	540	1468.68	734.34	2695.03
2	"	<i>Lannea barteri</i>	151	17793.2172	540	9608.34	4804.17	17631.30
3	"	<i>Lannea welwitschii</i>	1376	42109.609	640	26950.15	13475.07	49453.52
4	"	<i>Mangifera indica</i>	956	55107.7902	640	35268.99	17634.49	64718.59
5	"	<i>Pseudospondias microcarpa</i>	3	353.5077	695	245.69	122.84	450.84
6	"	<i>Spondias mombin</i>	403	26546.466	464	12317.56	6158.78	22602.72
7	Annonaceae	<i>Cleistopholis libericus</i>	16	304.36	410	124.79	62.39	228.99
8	"	<i>Cleistopholis patens</i>	872	53562.775	410	21960.74	10980.37	40297.95
9	Apocynaceae	<i>Alstonia boonei</i>	1014	8975.4154	430	3859.43	1929.71	7082.05
10	"	<i>Alstonia congonesis</i>	1412	84924.38	432	36687.33	18343.67	67321.25
11	"	<i>Funtumia elastica</i>	6961	414449.504	450	186502.28	93251.14	342231.68
12	"	<i>Holarrhena floribunda</i>	18	318.6	540	172.04	86.02	315.70
13	Arecaceae	<i>Hyphaena thebaica</i>	3	353.5077	640	226.24	113.12	415.16
14	Bignoniaceae	<i>Nevebouldia laevis</i>	1	0.91	540	0.49	0.25	0.90
15	"	<i>Spathodea campanulata</i>	5	589.1795	340	200.32	100.16	367.59
16	Bombacaceae	<i>Bombax buonopozense</i>	827	11127.6981	330	3672.14	1836.07	6738.38
17	"	<i>Ceiba pentandra</i>	16875	640021.04	260	166405.47	83202.74	305354.04
18	Boraginaceae	<i>Cordia millenii</i>	955	36541.2559	340	12424.03	6212.01	22798.09
19	"	<i>Cordia platythyrso</i>	2	5.85	340	1.99	0.99	3.65
20	"	<i>Corynanthe pachyceras</i>	2183	49.5	640	31.68	15.84	58.13
21	"	<i>Crossopteryx febrifuga</i>	1	117.8359	640	75.41	37.71	138.39
22	"	<i>Cylicodiscus gabunensis</i>	7	824.8513	640	527.90	263.95	968.71
23	Burseraceae	<i>Canarium africana</i>	6	2.72	450	1.22	0.61	2.25
24	"	<i>Canarium schweinfurthii</i>	588	10209.3997	479	4890.30	2445.15	8973.71
25	"	<i>Carapa procerra</i>	593	386.2877	550	212.46	106.23	389.86
26	"	<i>Cassia nodosa</i>	8	5.45	630	3.43	1.72	6.30
27	"	<i>Cassia siamea</i>	5307	303221.73	780	236512.95	118256.47	434001.26
28	"	<i>Cassia sieberiana</i>	389	45838.165	640	29336.43	14668.21	53832.34
29	Caesalpiniaceae	<i>Combretodendron macrocarpum</i>	250	1545.511	460	710.94	355.47	1304.57
30	"	<i>Erythrophleum africanum</i>	10	46.08	600	27.65	13.82	50.73
31	"	<i>Erythrophleum ivorensis</i>	2288	132609.283	832	110330.92	55165.46	202457.24
32	Caesalpinoideae	<i>Daniellia ogea</i>	6442	341500.77	550	187825.42	93912.71	344659.65
33	"	<i>Daniellia oliveri</i>	499	31115.01	550	17113.26	8556.63	31402.82
34	"	<i>Delonix regia</i>	86	4913.7119	485	2383.15	1191.58	4373.08
35	"	<i>Detarium microcapum</i>	5563	317848.6	640	203423.10	101711.55	373281.40
36	"	<i>Dialium guineensis</i>	5536	313035.535	640	200342.74	100171.37	367628.93
37	"	<i>Hylondendron gabunense</i>	359	41378.29	640	26482.11	13241.05	48594.66
38	Chrysobalanaceae	<i>Parinari congensis</i>	1	0.91	540	0.49	0.25	0.90
39	"	<i>Parinari excelsa</i>	1	117.8359	540	63.63	31.82	116.76
40	Combretaceae	<i>Anogeissus leiocarpa</i>	6685	387606.24	720	279076.49	139538.25	512105.36
41	"	<i>Terminalia ivorensis</i>	3013	55812.551	625	34882.84	17441.42	64010.02
42	"	<i>Terminalia superba</i>	3518	106576.16	540	57551.13	28775.56	105606.32
43	Connaraceae	<i>Byrsocarpus coccineus</i>	2	235.6718	720	169.68	84.84	311.37
44	Cucurbitaceae	<i>Momordica cabraei</i>	93	10958.74	640	7013.59	3506.80	12869.94
45	Ebenaceae	<i>Diospyros canaliculata</i>	2	235.6718	720	169.68	84.84	311.37
46	"	<i>Diospyros monbuttensis</i>	103	5778.6582	864	4992.76	2496.38	9161.72
47	"	<i>Drypetes paxii</i>	1	117.8359	700	82.49	41.24	151.36

Table 2. Continued

S/N	Family	Tree Species	Number of tree	Volume (m ³)	Density (kg/m ³)	Biomass (tons)	Carbon stock (tons)	CO ₂ (tons)
48	<i>Euphorbiaceae</i>	<i>Bridelia artroviridis</i>	1	0.91	470	0.43	0.21	0.78
49	"	<i>Bridelia ferruginea</i>	440	25139.921	470	11815.76	5907.88	21681.92
50	"	<i>Bridelia micrantha</i>	1	117.8359	470	55.38	27.69	101.63
51	"	<i>Butyrospermum paradoxum</i>	5438	310767.2759	720	223752.44	111876.22	410585.72
52	"	<i>Hevea brasiliensis</i>	4	471.3436	660	311.09	155.54	570.84
53	"	<i>Macaranga barteri</i>	3	353.5077	640	226.24	113.12	415.16
54	"	<i>Phyllanthus angolensis</i>	1	0.91	544	0.50	0.25	0.91
55	"	<i>Phyllanthus discoides</i>	1035	363.3	760	276.11	138.05	506.66
56	"	<i>Ricinodendrum heudelotti</i>	4013	241006.1	200	48201.22	24100.61	88449.24
57	<i>Fabaceae</i>	<i>Afrormosia elata</i>	4756	145.2	640	92.93	46.46	170.52
58	"	<i>Afzelia africana</i>	3512	196105.108	780	152961.98	76480.99	280685.24
59	"	<i>Albizia zygia</i>	27	2686.85	470	1262.82	631.41	2317.27
60	"	<i>Albizia ferruginea</i>	59	6952.318	550	3823.77	1911.89	7016.63
61	"	<i>Albizia lebeck</i>	3495	94165.68	590	55557.75	27778.88	101948.47
62	"	<i>Albizia zygia</i>	5440	292533.7	470	137490.84	68745.42	252295.69
63	"	<i>Gossweilerodendron balsamiferon</i>	104	6.9	640	4.42	2.21	8.10
64	"	<i>Milletia griffoniana</i>	2	235.6718	640	150.83	75.41	276.77
65	"	<i>Milletia thonningii</i>	9261	190316.675	632	120280.14	60140.07	220714.05
66	"	<i>Parkia biglobosa</i>	56	5661.123	540	3057.01	1528.50	5609.61
67	"	<i>Parkia clappertoniana</i>	5280	301679.05	440	132738.78	66369.39	243575.66
68	"	<i>Pterocarpus erinaceus</i>	10	1178.359	640	754.15	377.07	1383.86
69	"	<i>Pterocarpus osun</i>	446	26089.736	640	16697.43	8348.72	30639.79
70	"	<i>Pterocarpus santalinoides</i>	4904	1696.1672	640	1085.55	542.77	1991.98
71	"	<i>Pycnanthus angolensis</i>	1845	55920.018	544	30420.49	15210.24	55821.60
72	<i>Flacourtiaceae</i>	<i>Scottellia coriacea</i>	45	5302.615	640	3393.67	1696.84	6227.39
73	<i>Glusiaceae.</i>	<i>Allanblankia floribunda</i>	2	0.91	860	0.78	0.39	1.44
74	<i>Guttiferae</i>	<i>Garcinia smeathmannii</i>	1	117.8359	640	75.41	37.71	138.39
75	"	<i>Symphonia globulifera</i>	18	599.18	470	281.61	140.81	516.76
76	<i>Humiriaceae</i>	<i>Sacoglottis gabonensis</i>	2	1.82	540	0.98	0.49	1.80
77	"	<i>Irvingia gabonensis</i>	19	1142.6613	900	1028.40	514.20	1887.11
78	"	<i>Irvingia wombulu</i>	2948	19089.386	900	17180.45	8590.22	31526.12
79	<i>Leguminosae</i>	<i>Brachystegia eurycoma</i>	4877	66030.199	600	39618.12	19809.06	72699.25
80	"	<i>Distemonanthus benthamianus</i>	1434	4558.3112	640	2917.32	1458.66	5353.28
81	"	<i>Erythrina senegalensis</i>	10	1178.359	640	754.15	377.07	1383.86
82	<i>Loganiaceae</i>	<i>Anthocleista procera</i>	20	2356.718	640	1508.30	754.15	2767.73
83	"	<i>Anthocleista schweinfurthii</i>	3142	179521.89	640	114894.01	57447.00	210830.51
84	"	<i>Anthostema aubreyanum</i>	6	707.0154	640	452.49	226.24	830.32
85	<i>Malvaceae</i>	<i>Cola lateritia</i>	6	122.3959	640	78.33	39.17	143.74
86	"	<i>Cola gigantia</i>	3172	202387.59	460	93098.29	46549.15	170835.36
87	"	<i>Cola nitida</i>	141	16614.86	640	10633.51	5316.76	19512.49
88	"	<i>Hildegardia barteri</i>	4	471.3436	640	301.66	150.83	553.55
89	<i>Meliaceae</i>	<i>Azadiracta indica</i>	93	5257.439	840	4416.25	2208.12	8103.82
90	"	<i>Entandrophragma cylindricum</i>	541	17657.6515	592	10453.33	5226.66	19181.86
91	"	<i>Entandrophragma utile</i>	3199	3828.0895	832	3184.97	1592.49	5844.42
92	"	<i>Guarea cedrata</i>	7573	198.57	635	126.09	63.05	231.38
93	"	<i>Guarea thomsonii</i>	10	1178.359	635	748.26	374.13	1373.05
94	"	<i>Khaya grandifoliola</i>	767	6136.809	720	4418.50	2209.25	8107.95

Table 2. Continued

S/N	Family	Tree Species	Number of tree	Volume (m ³)	Density (kg/m ³)	Biomass (tons)	Carbon stock (tons)	CO ₂ (tons)
95	"	<i>Khaya ivorensis</i>	402	36410.11	530	19297.36	9648.68	35410.65
96	"	<i>Khaya senegalensis</i>	5587	134180.238	550	73799.13	36899.57	135421.41
97	"	<i>Lorvoa trichilioides</i>	2040	211.32	582	122.99	61.49	225.68
98	"	<i>Milicia excelsa</i>	6269	263188.81	632	166335.33	83167.66	305225.33
99	"	<i>Trichilia emetica</i>	6	707.0154	608	429.87	214.93	788.80
100	"	<i>Trichilia lanata</i>	3	870.21	540	469.91	234.96	862.29
101	"	<i>Trichilia monadelpha</i>	7	824.8513	608	501.51	250.75	920.27
102	Mimosoideae	<i>Acacia senegalensis</i>	9	597.5795	570	340.62	170.31	625.04
103	"	<i>Piptandeniastrum africanum</i>	1043	16968.8881	695	11793.38	5896.69	21640.85
104	Moraceae	<i>Antiaris africana</i>	4788	312990.86	430	134586.07	67293.03	246965.44
105	"	<i>Artocarpus altillis</i>	247	28871.61	310	8950.20	4475.10	16423.62
106	"	<i>Astonia congensis</i>	634	288.7	460	132.80	66.40	243.69
107	"	<i>Ficus capensis</i>	21	717.0154	540	387.19	193.59	710.49
108	"	<i>Ficus exasperata</i>	10402	225599.643	600	135359.79	67679.89	248385.21
109	"	<i>Ficus thonningii</i>	2	235.6718	640	150.83	75.41	276.77
110	"	<i>Morus mesozygia</i>	4259	243155.163	230	55925.69	27962.84	102623.64
111	Myristicaceae	<i>Coelocaryon preussii</i>	64	3656.7158	640	2340.30	1170.15	4294.45
112	Myrtaceae	<i>Syzgium oswariense</i>	879	50222.706	460	23102.44	11551.22	42392.99
113	"	<i>Syzgium guineense</i>	1	117.8359	665	78.36	39.18	143.79
114	Ochnaceae	<i>Lophira alata</i>	1745	972.95	800	778.36	389.18	1428.29
115	Olacaceae	<i>Strombosia graandifolia</i>	3	2.73	816	2.23	1.11	4.09
116	"	<i>Strombosia pustulata</i>	1041	21.1	804	16.96	8.48	31.13
117	Palmea	<i>Borassus aethiopum</i>	1214	971.0772	640	621.49	310.74	1140.43
118	"	<i>Bosqueia angolensis</i>	666	50750.099	600	30450.06	15225.03	55875.86
119	Papilionaceae	<i>Baphia pubescens</i>	2	235.6718	640	150.83	75.41	276.77
120	"	<i>Berlinia confusa</i>	753	5033.2653	640	3221.29	1610.64	5911.07
121	"	<i>Berlinia congolensis</i>	1	117.8359	690	81.31	40.65	149.20
122	"	<i>Berlinia coriacea</i>	84	9898.215	690	6829.77	3414.88	12532.62
123	"	<i>Berlinia grandiflora</i>	192	22788.149	690	15723.82	7861.91	28853.21
124	"	<i>Lonchocarpus sericeus</i>	166	5990.633	540	3234.94	1617.47	5936.12
125	Papilionoideae	<i>Amphimas pterocarpoides</i>	3384	72793.189	880	64058.01	32029.00	117546.44
126	Phyllanthaceae	<i>Margaritaria discoidea</i>	6	707.0154	640	452.49	226.24	830.32
127	Rhabdodermatidae	<i>Trilepisium madagacariense</i>	6	707.0154	518	366.23	183.12	672.04
128	Rhizophoraceae	<i>Cassipourea barteri</i>	1	117.8359	640	75.41	37.71	138.39
129	"	<i>Cedrella odorata</i>	73	4114.7153	390	1604.74	802.37	2944.70
130	Rubiaceae	<i>Anthocleista djalensis</i>	19	2238.882	640	1432.88	716.44	2629.34
131	"	<i>Mitragyna ciliata</i>	4149	5865.5469	640	3753.95	1876.98	6888.50
132	"	<i>Mitragyna stipulosa</i>	8365	504.2477	470	237.00	118.50	434.89
133	"	<i>Nauclea diderrichii</i>	7587	1655.0536	780	1290.94	645.47	2368.88
134	"	<i>Pausinystalia johimbe</i>	2479	51.8	640	33.15	16.58	60.83
135	Rutaceae	<i>Fagara rubescens</i>	17	363.0577	470	170.64	85.32	313.12
136	"	<i>Fagara santalinoides</i>	161	18971.58	640	12141.81	6070.91	22280.22
137	"	<i>Detarium microcarpum</i>	1352	57531.6429	690	39696.83	19848.42	72843.69
138	Sapindaceae	<i>Blighia sapida</i>	1484	87985.671	750	65989.25	32994.63	121090.28
139	Sapotaceae	<i>Aningeria robusta</i>	11	123.2759	640	78.90	39.45	144.78
140	"	<i>Chrysophyllum albidum</i>	1979	95421	560	53435.76	26717.88	98054.62
141	"	<i>Chrysophyllum delevoiyi</i>	1	3.02	560	1.69	0.85	3.10

Table 2. Continued

S/N	Family	Tree Species	Number of tree	Volume (m ³)	Density (kg/m ³)	Biomass (tons)	Carbon stock (tons)	CO ₂ (tons)
142	"	<i>Vitellaria paradoxa</i>	1	117.8359	640	75.41	37.71	138.39
143	<i>Simaroubaceae</i>	<i>Hannoa ferruginea</i>	21	143.4359	540	77.46	38.73	142.13
144	"	<i>Hannoa klaineana</i>	1179	34715.359	640	22217.83	11108.91	40769.72
145	"	<i>Hannoa undulata</i>	85	10016.05	540	5408.67	2704.33	9924.90
146	<i>Sterculiaceae</i>	<i>Mansonia altissima</i>	637	24578.6954	672	16516.88	8258.44	30308.48
147	"	<i>Nesogordonia papaverifera</i>	1036	17580.876	784	13783.41	6891.70	25292.55
148	"	<i>Pterygota macrocarpa</i>	1837	34565.1266	592	20462.55	10231.28	37548.79
149	"	<i>Sterculia oblonga</i>	1120	5017.0671	600	3010.24	1505.12	5523.79
150	"	<i>Sterculia rhinoptela</i>	644	28112.92	640	17992.27	8996.13	33015.81
151	"	<i>Sterculia tragacantha</i>	278	5901.0666	640	3776.68	1888.34	6930.21
152	"	<i>Triplochiton scleroxylon</i>	2195	104983.86	384	40313.80	20156.90	73975.83
153	<i>Ulmaceae</i>	<i>Celtis adolfi-friderrei</i>	5	589.1795	832	490.20	245.10	899.51
154	"	<i>Celtis zenkerii</i>	2983	150401.7287	832	125134.24	62567.12	229621.33
155	"	<i>Holoptelea grandis</i>	1085	16650.6	650	10822.89	5411.45	19860.00
156	<i>Verbenaceae</i>	<i>Gmelina arborea</i>	102	4359.153	540	2353.94	1176.97	4319.48
157	"	<i>Tectona grandis</i>	15	1161.8	660	766.79	383.39	1407.06
158	"	<i>Vitex doniana</i>	11	1296.195	510	661.06	330.53	1213.04
159	"	<i>Vitex grandifolia</i>	41	4127.426	540	2228.81	1114.41	4089.87
160	"	<i>Vitex simplicifolia</i>	5465	309900.44	510	158049.22	79024.61	290020.33
161	"	<i>Other spp</i>	859	5678.09	640	3633.98	1816.99	6668.35
Total			246786	8321595.64		4560724.36	2280362.18	8368929.20
Mean			82262	2773865.21		1520241.45	760120.73	2789643.10

CO₂ (0.65 tons). In Osun State, *Ceiba pentandra* that was also the most exploited species had the highest amount of CO₂ (145,185.92 tons). This was followed by *Milicia excelsa* (135,174.97 tons) and the least exploited species was *Cola millenii* also had the least amount of CO₂ (70.06 tons). In Ekiti State, *Antiaris africana* (39,680.58 tons) and *Dialium guineense* (32,655.87 tons) has the highest carbon release while the least carbon release was recorded for *Baphia spp* (1.77 tons).

On the whole, the total number of timber removed from the selected states' forests stood at about 246,885 trees, belonging to 161 different species and 45 families. This amounted to an annual removal of about 82262 trees. The total volume of logs exploited in the study area for the three year period stood at 8.3 million m³ and the annual removal is 2.8million m³. The results revealed that *Ceiba pentandra* was the most exploited tree species in the zone with annual cut of about 5,625 trees with an annual volume of 213,340.35 m³. This is followed by *Ficus exasperata* with an annual cut of 3,467 trees and a volume of 75,199.88 m³.

The total biomass estimate of the trees from the selected forests for the 3-year period when their respective density values were applied was 4.64 Gt, with an annual tree biomass removal of 1.52 metric tons.

After the total volume of wood was converted to biomass for carbon estimation, the quantum of carbon represented by the total removal for the 3-year period was estimated and it stood at 2.3million metric tons from the 246,885 trees of the different tropical indigenous hardwood species. The annual carbon release therefore stood at 760,120.73 metric tons from a yearly cut of 82,262 trees. The estimated carbon in the logged woods was subsequently used to obtain the quantity of CO₂ that the logged woods have the capacity of absorbing from the atmosphere. This translated to a total of 8.5million metric tons of CO₂, for the 3-year period, that the removed woods of this region have the ability to sequester if they were to remain live standing trees. If these woods were burnt, about this amount of CO₂ would have been released into the atmosphere. The annual carbon and CO₂ equivalents are 760,120.73 metric tons and 2,789,643.10

Table 3. Summary of result for the number of stems, volume and CO₂ released from the study area

State	Mean no of stems	No of species	No of families	Mean volume	Biomass	Carbon	Mean CO ₂
Oyo	4756±300.47 ^a	58	29	271724.46±17167.82 ^a	1586730.20±12273.10 ^a	79336.51±6136.55 ^a	291164.00±22521.13 ^a
Osun	814±132.25 ^b	130	42	102057.75±16804.84 ^b	450915.86±4256.05 ^b	22545.79±2128.03 ^b	88121.99±8830.20 ^b
Ondo	4102±511.67 ^a	61	24	16017.69±2776.92 ^c	86873.29±1381.41 ^c	4343.67±690.71 ^c	15941.25±2534.89 ^c
Ogun	23±1.12 ^c	74	33	1427.42±189.24 ^d	7011.57±73.21 ^d	350.58±36.60 ^d	1286.62±134.33 ^d
Ekiti	808.27±80.11 ^b	60	25	7497.41±2566.27 ^c	44529.55±1615.83 ^c	2226.48±807.92 ^c	7848.25±134.33 ^c

*Means in the same column with the same superscript are not significantly different ($p > 0.05$).

metric tons respectively. It should be noted however that these estimates were for timbers legally removed and recorded in the department's monthly report of timber felled in the States. They were those removed by timber contractors or concessionaires with all necessary permits obtained from the government. There were no records for all the logs that were illegally removed from the reserves and those felled from the free areas.

The results of the one way analysis of variance revealed a significant difference ($p < 0.05$) in the number of trees, number of species, number of families, volume, biomass, carbon and the amount of CO₂ released from the logged trees in the states. However, the estimates of these variables were found to be significantly higher in Oyo State when compared with the other four states. According to the mean separation results, there was significant difference ($p > 0.05$) in all these variables as shown in Table 3. Also, the list of ten most exploited tree species in each State is presented in Table 4. According to the Table, *Mitragyna stipulosa* (8,353) recorded the highest number of exploitation for the three years period in Ondo State. In Oyo State, *Anogeissus leicocarpus* (6,590), had the highest number of exploitation but Osun, Ogun and Ekiti State, *Ceiba pentandra* was most exploited as presented in the Table.

Discussion

Trees exploited from the forests of South-West Nigeria by loggers were majorly tropical hardwood species of economic and timber values. Nowadays, virtually all species of trees including the lesser known and those that were not regarded as durable ones in the past are now logged for sawn wood production. This was due to the fact that the most

economic species are disappearing due to high demand. In Nigeria, logging is usually from the forest reserves and the free areas. There are a total of 1600 productive forest reserves in Nigeria but their numbers and sizes varied from one state to the other. It has been reported that some of them only exist today on paper (Oyebo 2008). Apart from the wanton and indiscriminate logging activities, which had led to the degradation and destruction of most of these reserves, there are also the problems of encroachment and conversion to farmland by landless farmers and replacement with plantations of fast growing exotic species by the large-scale afforestation projects of both the State and Federal government. Two of the reserves in the zone (Omo and Oluwa Forest Reserves in Ondo and Ogun States, respectively) have been converted to large-scale afforestation projects of the government. These were the largest and most diverse forest reserves in the tropical rainforest ecosystem of southwest Nigeria. The fact that there is the scarcity of the most desirable species for timber production in the country today has resulted into having *Ceiba pentandra*, a species with poor timber quality and durability, as the most exploited species in the zone. This species has found its way to the timber market and even became very popular today.

We discovered that Ogun, the state with the largest forestland area, produced the least amount of annual timber. This may be due to the fact that the largest single forest reserve in the state (Omo Forest reserve) has an active large afforestation project. This large forest reserve that ought to be a good source of indigenous timber now housed a very large hectare of plantations of *Gmelina arborea* and *Nauclea diderrichii* under the World Bank Afforestation project with counterpart funding from the Federal Government of

Table 4. Ten most exploited species in each of the studied States

S/N	Oyo state		Ondo state		Ogun state		Osun state		Ekiti state	
	Tree species	No of stem	Tree species	No of stem	Species	No of stem	Species	No of stem	Species	No of stem
1	<i>Anogeissus leiocarpus</i>	6590	<i>Mitragyna stipulosa</i>	8352	<i>Ceiba pentandra</i>	30	<i>Ceiba pentandra</i>	2426	<i>Ceiba pentandra</i>	1584
2	<i>Ceiba pentandra</i>	5693	<i>Nuclea diderichi</i>	7574	<i>Terminalia superba</i>	29	<i>Antiaris africana</i>	1211	<i>Albizia zygia</i>	1186
3	<i>Funtumia elastica</i>	5669	<i>Guarea cedrata</i>	7570	<i>Ricinus dron africanum</i>	29	<i>Ricinus dron heudelotti</i>	1122	<i>Antiaris africana</i>	1160
4	<i>Zanthoxylum zanthoxyloides</i>	5563	<i>Ceiba pentandra</i>	7142	<i>Antiaris africana</i>	28	<i>milicia excelsa</i>	865	<i>Ricinus dron spp</i>	934
5	<i>Bulbosperrum paradoxum</i>	5437	<i>Ficus exasperata</i>	6656	<i>Albizia zygia</i>	27	<i>Albizia zygia</i>	846	<i>Celtis zenkeri</i>	882
6	<i>Vitex simplicifolia</i>	5421	<i>Millatia thomlingii</i>	5958	<i>Daniella ogea</i>	26	<i>Albizia spp</i>	760	<i>Dialium guineense</i>	858
7	<i>Daniella ogea</i>	5412	<i>Afromosia elata</i>	4756	<i>Piptadeniastrum africanum</i>	24	<i>Ficus spp</i>	721	<i>Ficus exasperata</i>	766
8	<i>Cassia siamea</i>	5307	<i>Pterocarpus santalinoides</i>	4742	<i>Alstonia congensis</i>	22	<i>Celtis spp</i>	697	<i>Khaya grandis</i>	748
9	<i>Parkia clappertoniana</i>	5280	<i>Mitragyna ciliata</i>	4062	<i>Pterygota macrocarpa</i>	21	<i>Funtumia elastica</i>	693	<i>Alstonia congensis</i>	704
10	<i>Macaranga barteri</i>	4237	<i>Brachystegia eurycoma</i>	3525	<i>Hannoa ferruginea</i>	20	<i>Alstonia congensis</i>	686	<i>Pterygota macrocarpa</i>	609

Nigeria and Ogun State Government. In addition, the relics of the reserve have been put under strict protection and constituted as Biosphere reserve by the Forestry Research Institute of Nigeria. The few cut recorded in the state was from the few productive reserves in Ogun State. Bulk of the state's log supply is from the neighbouring states.

In Nigeria, logging policy has to do with the allocation of compartments to concessionaires by the Forestry Department after the payment of all necessary levies. Logging in each compartment is through selective method. The involvement of the government in logging activities in the free areas (unreserved forests) is limited to issuance of log certificate after the production of owner's consent by the loggers. There are so many ecological and social problems with unsustainable logging in the reserves due to lack of former education and training for loggers and operators of felling machines, poor skidding methods, improper supervision by forest officers and corruption of some government forest staff. Some of the consequences of logging in the tropical rainforest ecosystem of south west Nigeria were reported by Adekunle and Ige (2006) and Adekunle and Olagoke (2010) to include loss of biodiversity, compaction of soil, destruction of the home of wildlife, opening of forest to encroachers and farmers and global warming.

The colossal annual volume of timber (8.2 million cubic meters) and the high number of trees (231,000) that were removed from the forest ecosystem according to this study are detrimental to forest conservation for posterity, ecological and environmental benefits. With this present rate of logging in Nigeria, it seems that forest degradation is being disregarded. As a result, Nigerian forests are losing much of their carbon. This is very inimical to the implementation of the REDD agreement. There is also the loss of biodiversity and other ecosystem services, when valuable trees are harvested without regard to the ecological consequences (Broadbent et al. 2008; Schwenk et al. 2012). Meyfroidt and Lambin (2008) stated that political instability and governance failures, wildfires as well as the uncontrolled and often illegal logging usually result in forest degradation and deforestation, which has continued unabated in the tropics. Oyebo (2006) puts the annual deforestation rate in Nigeria at 3%. Similarly, Bond et al. (2009) reported that logging and poor management is leading to the loss of approximately 400,000 hectares of tropical forest in the Congo

Basin each year. Therefore, the problems of unsustainable logging are common scenario in most developing countries of West African sub-Sahara.

The contribution of big diameter logs in tropical rain-forest ecosystem to carbon stock cannot be overestimated (e.g. Slik et al. 2013). The annual and mean monthly carbon estimates from wood biomass in this study are very enormous for some species with large number of big trees. Wood density was reported to be an important factor in converting forest volume data to biomass (Feamside 1997). Carbon content presented in this study was obtained from biomass estimated as the product of volume and density (Petrri et al. 2007). High quantity carbon release estimated could be related to the huge annual timber harvest from the study forests. However, the results of this work aligned with the assertion of Sasaki and Putz (2009) that the evergreen forest holds an average above-ground carbon stock of 121.2 Mg C/ha of which 71.4 Mg C is in trees ≥ 45 cm DBH. It was also reported by Houghton (2003), Achard et al. (2004) and Gullison et al. (2007) that tropical deforestation and degradation globally will result in the release of an estimated 1.1–2.2 Pg Carbon/year (It should be noted however that 1 Pg C = 10^{15} g C). The amount of carbon obtained by Petrri et al. (2007) from live trees in a mixed deciduous forest was 71.6 metric tons/ha. But, Dahal (2008) reported that a single tree can absorb tons of CO₂ over its lifetime, and protecting a young plant and forests is equally important as planting. Based on our result, we inferred that there is increasing pressure on economic tree species and it is plausible that they are becoming scarce from the forests in Southwestern Nigeria. Normally if such species economic trees are still available in abundance and within reach, we opine that lower number of commonly less-utilized species like *Ceiba pentandra* would have been exploited. The total annual carbon obtained in this study is an estimate from logs removed legally for sawn wood production only. Data were not available for those removed illegally.

Illegal logging according to Auer et al. (2003) can be broadly defined as “large scale, destructive forest harvesting that transgresses the laws of the nation where said harvesting occurs. While Fuwape (2001), highlighted some causes of forest destruction to include illegal logging, accelerated urbanization, conversion of forest reserves to farmlands and housing estate, Contreras-Hermosilla (2003)

itemize some specific activities of illegal logging to include the following: logging protected species; duplication of felling licenses; girdling or ring-barking, to kill trees so that they can be legally logged; contracting with local entrepreneurs to buy logs from protected areas; logging in protected areas; logging outside concession boundaries; logging in prohibited areas such as steep slopes, riverbanks, and water catchments; removing under/oversized trees from public forests; extracting more timber than authorized; reporting high volumes of timber extracted in forest concessions to mask the volume taken from areas outside concession boundaries and obtaining logging concessions through bribes. Consequently, each day at least 80,000 acres (32,300 ha) of forest either disappear or degraded from the Earth (Imeht and Adebobola 2001). The planet loses as many as several hundred species to extinction, the vast majority of which have never been documented by science and it is not even certain that all the Earth biodiversity would be documented before they are extinct.

As the forests are degraded, more carbon is added to the atmosphere, climatic conditions are further altered, and more topsoil is lost to erosion. Abubaka (2010) also reported that forest destruction is usually accompanied by reduction in species diversity, decrease in primary productivity, change in forest structure and depletion in soil nutrients. Poverty, corruption and population increase are some of the factors responsible for massive cut in Nigeria. Therefore to avert those consequences that may arise as a result of massive forest destruction, government should ensure that log harvesting is sustainable. Sustainable log harvesting can be achieved through the determination of an Allowable Annual Cut (AAC) and minimum dbh. An Allowable Annual Cut (AAC) refers to a harvest level that is partially calculated and then further adjusted to reflect socio-economic values and issues within the management unit for which it has been determined. The purpose of determining an AAC is to ensure that harvest levels does not exceed growing levels and that harvest levels are sustainable.

The results of this research indicated that the highest amount of carbon and CO₂ were in Oyo State where the highest number of logs were exploited. This could be attributed to the fact that the state has the highest population when compared with the other states. More wood and for-

estland are required by the large number of people in the state. IPCC (2001) attributed the rise in CO₂ concentration and emission to human activities such as burning of fossil fuel, land use change and deforestation. The anthropogenic activities such as slash and burn, fire management, timber harvesting (indiscriminate logging) and encroachment have accelerated the release of Green House Gases from the forests (Canadell et al. 2007). These activities are very rampant Nigerian forest estates and they resultantly have adverse effect on biodiversity conservation, ecosystem services and carbon storage. They are also very inimical to sustainable forest management. Furthermore, stand density was discovered to be a factor affecting the increase in carbon content of the location (Petsri et al. 2007).

The roles of forest ecosystem in the global carbon cycle cannot be over estimated. IPCC (2001) reported that forest stores about 80% of all above-ground and 40% of all below-ground terrestrial organic carbon. During productive season, it was claimed that CO₂ from the atmosphere is taken up by vegetation (Losi et al. 2003; Phat et al. 2004) and stored as plant biomass. In view of this, the UNFCCC and its Kyoto Protocol recognized the role of forests in carbon sequestration. Specifically, Article 3.3 and 3.4 of the Kyoto Protocol pointed out forest as potential carbon storage (Brown 2002). At the present rate of logging in the tropical forest ecosystem of south west Nigeria, coupled with all other sources of natural and human influences, much carbon is been released into the atmosphere than the amount needed by vegetation for photosynthesis. It has been reported that forest disturbances could lead to the release of carbon greater than what the plants will require for their regular activities (Brown 2002). Sustainable management strategies are therefore necessary to make the forest a carbon sink rather than source. Accounting for the carbon within forest ecosystems and changes in carbon stocks resulting from human activities is a necessary first step towards the better representation of forests in climate change policy at regional, national and global scales (Canadell et al. 2007). Hence, there is immediate need for the control of logging and forest degradation in the developing countries.

Conclusion and Recommendation

The role of forest ecosystem in carbon sequestration is

critical to climate change adaptation and mitigation. The huge volume of wood removed annually from the Nigerian tropical rainforest ecosystem as demonstrated in this study and other human activities are precursory to deforestation and carbon emission. Based on our result, we inferred that there is increasing pressure on economic tree species and it is plausible that they are becoming scarce from the forests in Southwestern Nigeria. If the present rate of log removal is not controlled, forests could become carbon source rather than carbon sink and the on biological conservation, wood availability and climate change may turn out grave. For the forest to perform its environmental role as carbon sink, urgent conservation measures and logging policies are needed to be put in place in this country. Indiscriminate Logging without regeneration negates the Clean Development Mechanism policy. As a result, urgent conservation measure is recommended. Also, appropriate logging policies in the reserves and free areas, afforestation and reforestation and awareness of the effect of the continuous logging activities on the climate should be put in place by all tiers of government and individual in sub Saharan Africa.

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